AGROFORESTRY SUMMARY

The proposed use of these trees in the San Joaquin Valley has taken two different directions, namely their use as salt tolerant plants when saline drainage water is used for irrigation and as vertical pumps. In both cases the trees ability to transpire large amounts of water is the primary reason for their adaptation to the agroforestry system. Economic benefits were also considered, but only as a secondary reason. Researchers in Australia have also been actively attempting to use trees and other woody species for the same purposes. In the SJV the primary purpose in the beginning was the use as salt tolerant plants to dispose of drainage water (Cervinka 1987), while in the land down under the original purpose seems to be the use as vertical pump (Biddiscombe et al., 1985; Greenwood, 1986). It might be well at this point to define the use as vertical pumps. Essentially, what is meant is that the trees are planted in slightly saline or non-saline soil where there is a shallow water table, within 1-3 meters of the surface. The trees are irrigated to become established and ultimately, their root system reaches the water table. The mature trees then draw upon the groundwater for their needs, hence controlling the level of the groundwater.

In Cervinka's program development for the SJV, trees had been planted on thirteen farms by 1987. Planting started in 1985 and the plantations had been irrigated with "fresh water immediately after planting" and "with drainage water after the first year". Research was also ongoing to select the most salt tolerant plant clones (Sachs and Cartwright, 1989), but the early salinity tolerance studies for *Eucalyptus camaldulensis* suggested that the levels of salt in the drainage water reduced growth rates by 70% in even the best selections.

In the winter of 1990 most of the eucalyptus were killed by a freeze dropping temperatures in the valley to 11 degrees Fahrenheit. Essentially, what was learned from the plantations established prior to this time was that growth rates and evapotranspiration (ET) dropped when the trees were irrigated with saline drainage water. Letey and Knapp (1995) used models to simulate Agroforestry water management, which also predicted the lowering of growth rates and ET. They showed that over time the drainage water applications quantities would increase leading to greater deep percolation,which would lead to the use of more land to dispose of the drainage water (Letey and Knapp, 1995). Since the primary purpose of these plantations was to dispose of drainage water lower growth and lower ET's defeat the purpose of planting trees, regardless of the species or the salt tolerance. The saline drainage water can cause the degradation of soil physical properties over time, reducing the water infiltration rates and reducing yield (Note: These physical properties are primarily at the surface. Tree canopy and lower story vegetation could actually prevent some of the degradation.)

This justifiably raises the question, if the soil physical properties are degraded using saline drainage water for irrigation does it matter what crop is to be grown and what the salt tolerance is for that crop?

Australian studies show that when trees are used as vertical pumps for long periods of time that the salt in the root zone gradually increases. Unless there is a mechanism to wash the salt from the tree root zone, it will ultimately increase until the salinity level is at a point beyond the tree's tolerance. First, the tree stops growing and transpiring removing its function as a vertical pump. Then, the tree dies. In November 1995, Tanji sampled trees and soils for salinity and boron. At the Britz farm in the San Joaquin Valley, five-year old *Eucalyptus camaldulensis* Lake Abacutcha, grown as "vertical pumps" were dead or dying. The soil profile under the worst looking tree was sampled and clearly showed a bulge in boron concentration from below the surface to about four feet. The highest boron reading was 37.8 mg/L at the 18 to 24 inch depth. EC_e readings also showed the same bulge with highest reading at the same depth of 22.3 dS/m. Similar symptoms could be observed at the Red Rock Ranch with two year old trees, not dying, but sickly. Soils below these trees also were beginning to show the bulge in EC_e and boron concentration.

Based upon the Austrailan work by Marcar et al. (1995) for drainage water reuse in the San Joaquin Valley of California, Birkle would make the following recommendations.

Acacia stenophylla is the most salt tolerant of the listed Acacias. It grows well on heavy clay soils and can tolerate freezing down to -6 °C and some water logging.

Acacia salicina is slightly less salt tolerant but also can withstand water logging, drought and some freezing.

Casuarina obesa tolerates mild freezing, drought, alkaline conditions and highly saline soils. The second *Casuarina* choice would be *glauca* as others of this species "become chlorotic in calcareous soils".

Eucalyptus kondininensis would be the first choice for the eucalypts based upon the information in the guidebook because it can tolerate some frost, drought, heavy clay and alkaline conditions. The drawback, it is slow growing and reaches only 10-15m (33-50 feet) in height.

Eucalyptus occidentalis is also drought hardy, frost tolerant and can grow in wet poorly drained soils. It can grow to 10-20 meters (33-66 feet) in height.

Eucalyptus sargentii is also drought tolerant, mildly frost tolerant, favors alkaline soil and is tolerant of periodic flooding.

Eucalyptus spathulata is less salt tolerant than the previous three, but is said to be adaptable to most soils and will tolerate heavy, alkaline, wet conditions. It is moderately frost tolerant.

Eucalyptus camaldulensis *is the most prominent tree that has been grown on agroforestry, (IFDM) sites in the San Joaquin Valley, but as mentioned above it has been found to be intolerant of the combination of soil flooding and saline water. The guidebook also indicates there is reduced growth when the soil EC exceeds 5 dS/m. It does mention that there are provenances that may be better suited to salt conditions. One prominent statement I find that may influence the choice of this tree is that it is <u>not well adapted to calcareous soils</u>.*

Melaleuca halmaturorum is the only member of this species to attempt growing for utilization of saline drainage water. It will tolerate water logging and is moderately frost tolerant.

The overall objective of the proposed research in the SJV was to determine the long-term feasibility of agroforestry (i.e. eucalyptus trees) as a method for reducing drainage volumes. It appears that water use is curtailed more than 50% for most conditions when saline water is used for irrigation.

Even though the SJV agroforestry projects have been concentrating on *Eucalyptus camaldulensis*, much of the salt tolerance in Australia and other countries seems to point to other species as being significantly more tolerant than *E. camaldulensis*. There seems to have been only limited trials on these other species in the SJV. There is additional support for using species other than Eucalyptus in drainage water reuse strategies.

Clones 4501 and 4573 of *Eucalyptus camaldulensis* appear to have greater salinity tolerance than the others such as 4544 and yet they were not used extensively in the field or the follow-up sand tank testing. There is some indication that clone 4590 may have the best relative yield with EC in the 4 –20 range, actually peaking at EC = 10 dS/m.

No woody species except possibly pistachio appears to have the economics for drainage water reuse. Bottom line, agroforestry as defined by Cervinka is not sustainable on either an economic basis or when salt tolerance is considered.